US008549813B2

(12) **United States Patent**
Martter

(10) **Patent No.: US 8,549,813 B2**
(45) **Date of Patent: *Oct. 8, 2013**

(54) **REINFORCING ASSEMBLY AND REINFORCED STRUCTURE USING A REINFORCING ASSEMBLY**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/187,311**

(22) Filed: **Jul. 20, 2011**

(65) **Prior Publication Data**

US 2012/0137619 A1 Jun. 7, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/959,912, filed on Dec. 3, 2010, now Pat. No. 8,220,219.

(51) **Int. Cl.**
E04H 12/00 (2006.01)

(52) **U.S. Cl.**
USPC **52/649.1**; 52/633

(58) **Field of Classification Search**
USPC 52/649.1, 633, 680, 677, 682, 687
See application file for complete search history.

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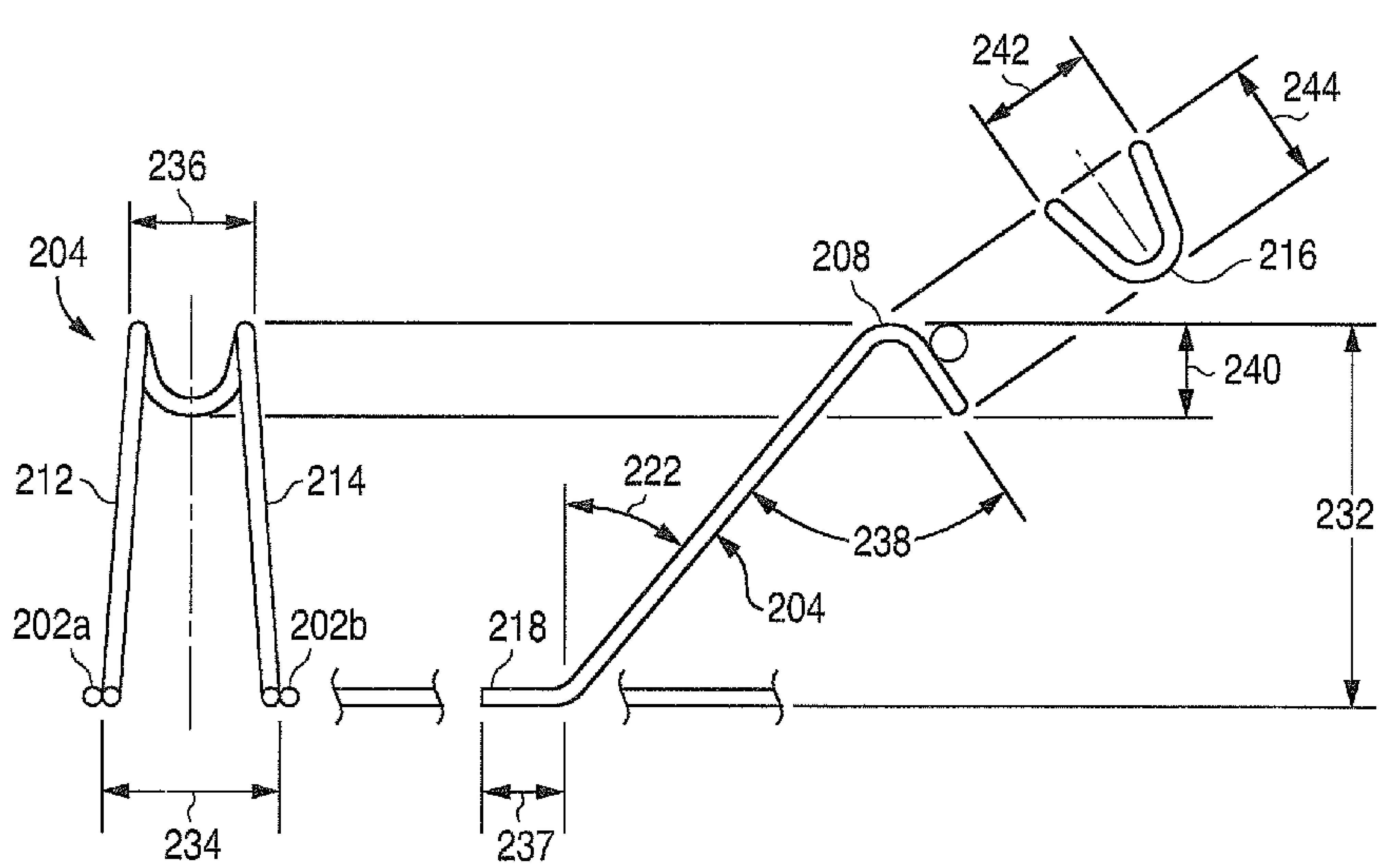
(57) **ABSTRACT**

A reinforcing assembly includes multiple spaced-apart, longitudinally-extending support bars. The reinforcing assembly also includes multiple working members each independently connected to the support bars. The working members are oriented diagonally with respect to a longitudinal axis extending along the reinforcing assembly.

21 Claims, 8 Drawing Sheets



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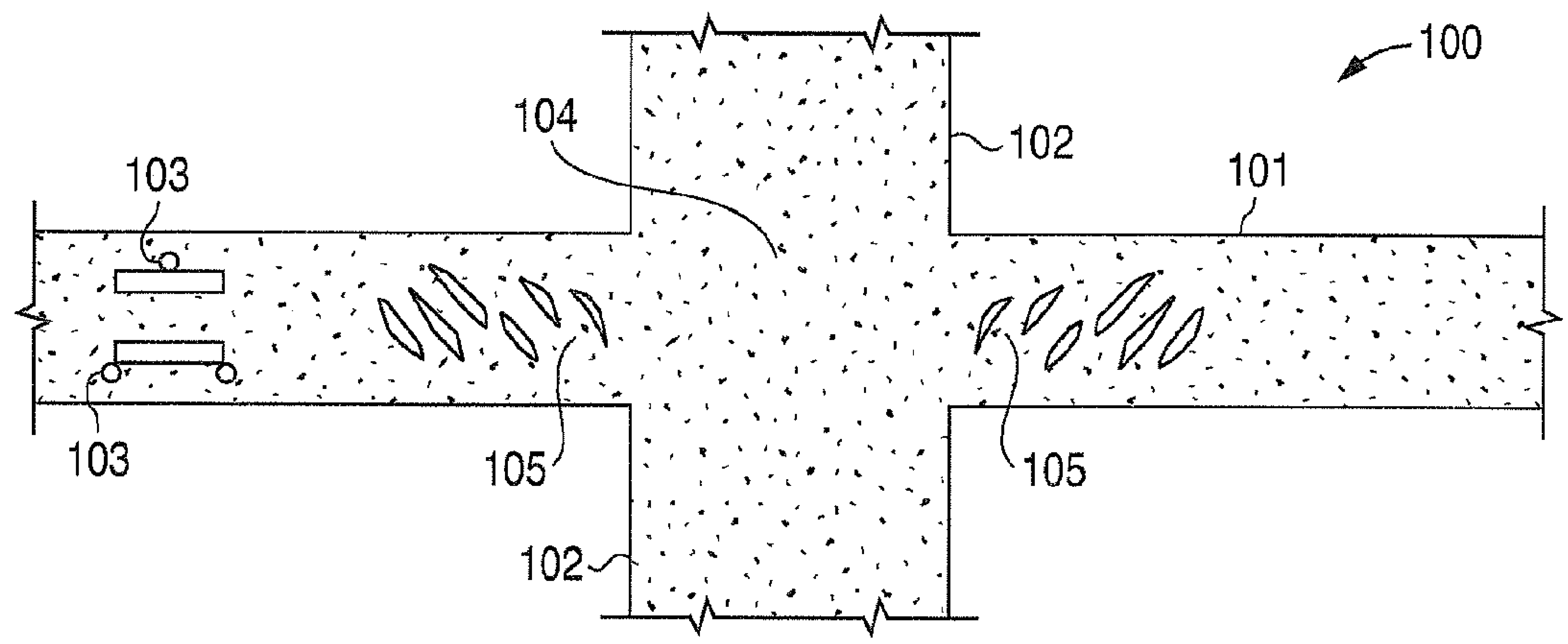
100
104
102
103
101
105
105
103
102

FIG. 1

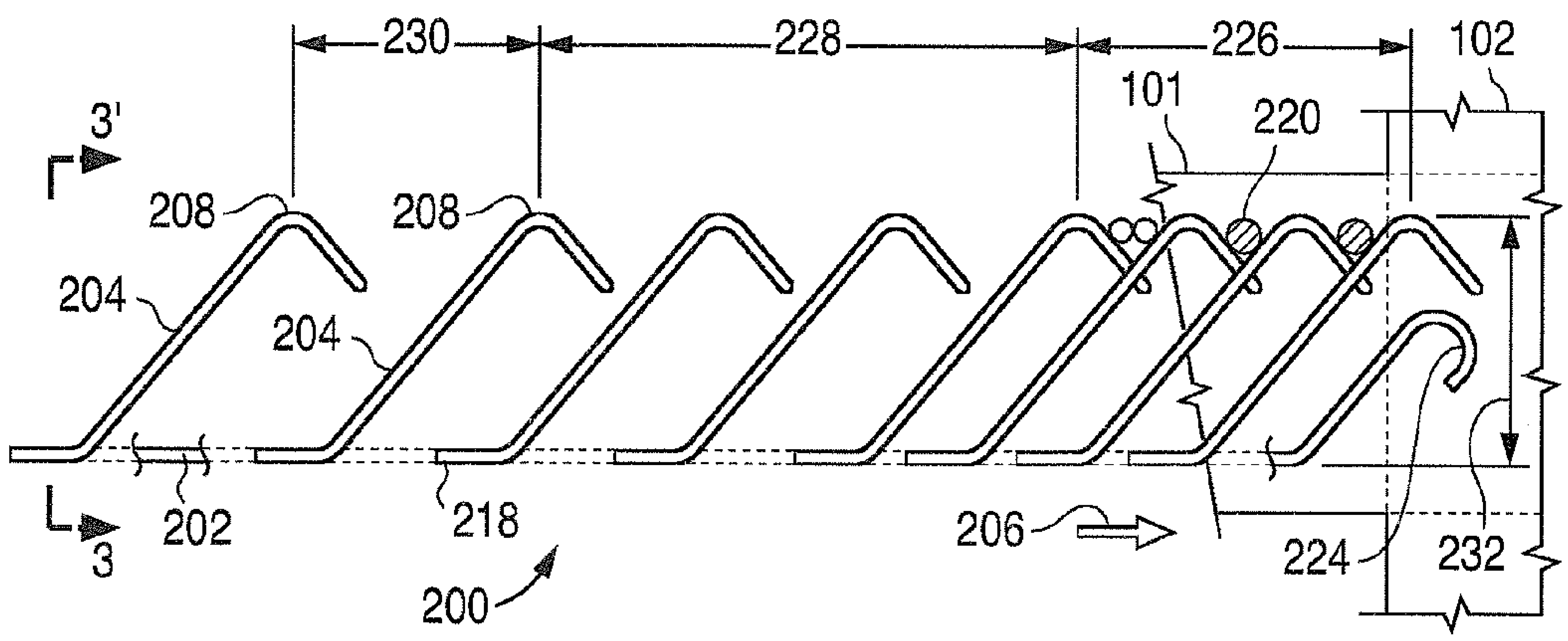
230
228
226
102
101
220
3'
208
208
204
204
202
218
206
224
232
3
200

FIG. 2

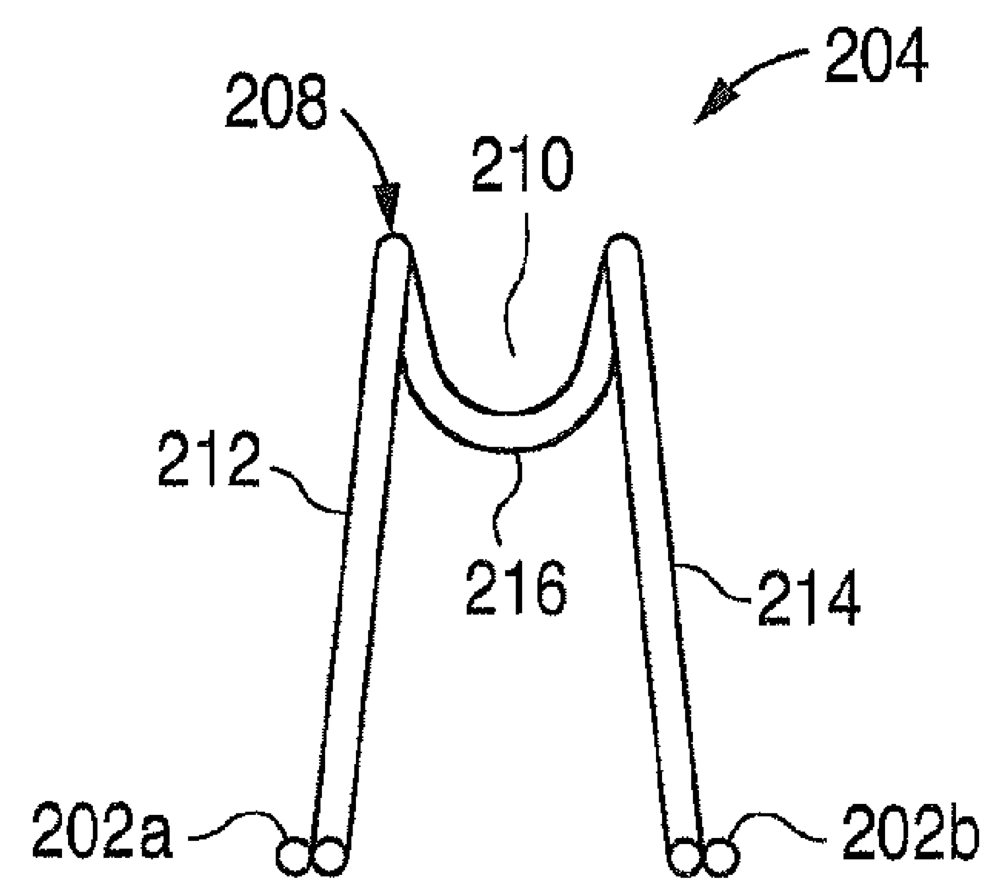
204
208
210
212
216
214
202a
202b

FIG. 3

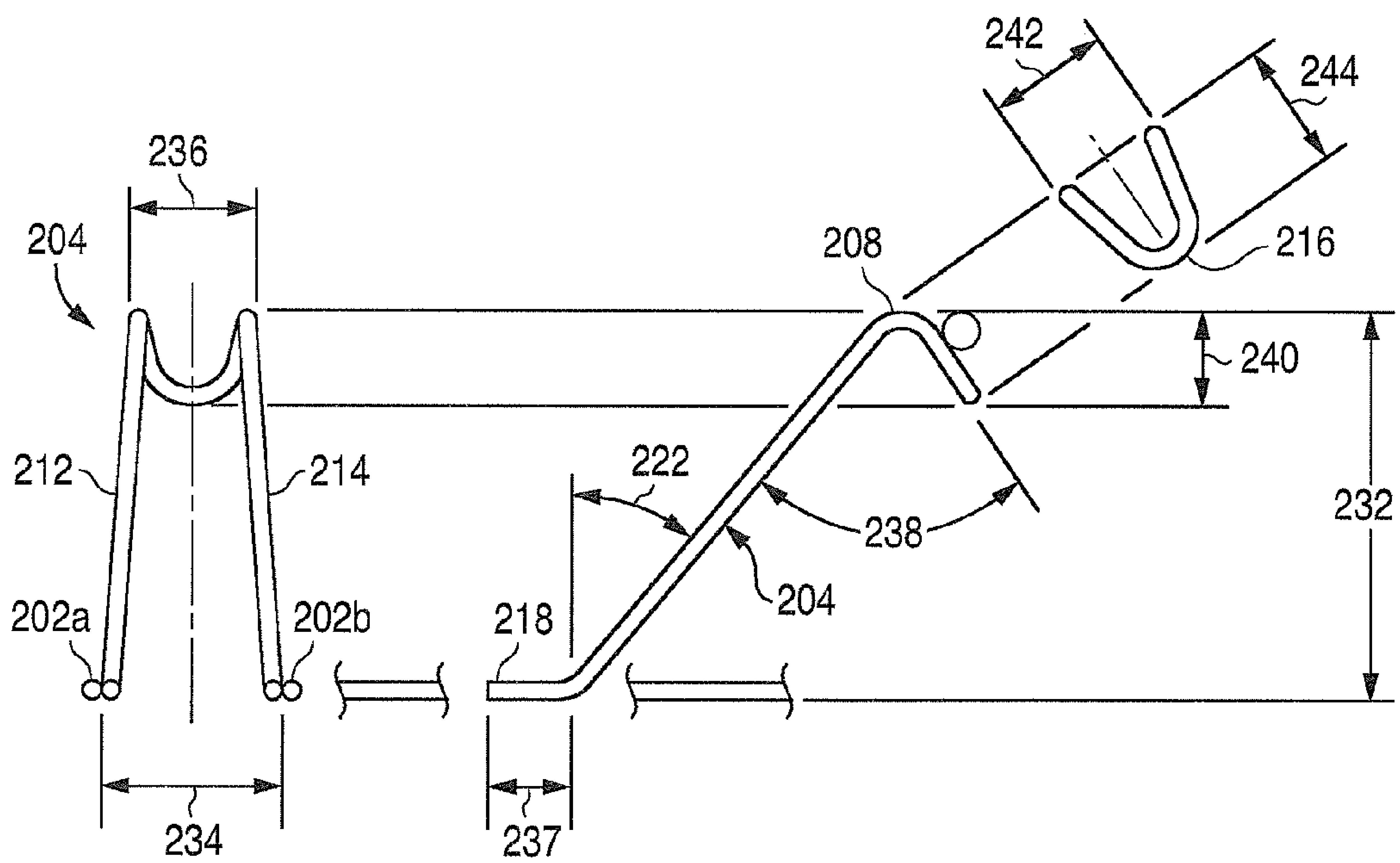
242
244
236
204
208
216
240
212
214
222
238
232
204
202a
202b
218
234
237

FIG. 4

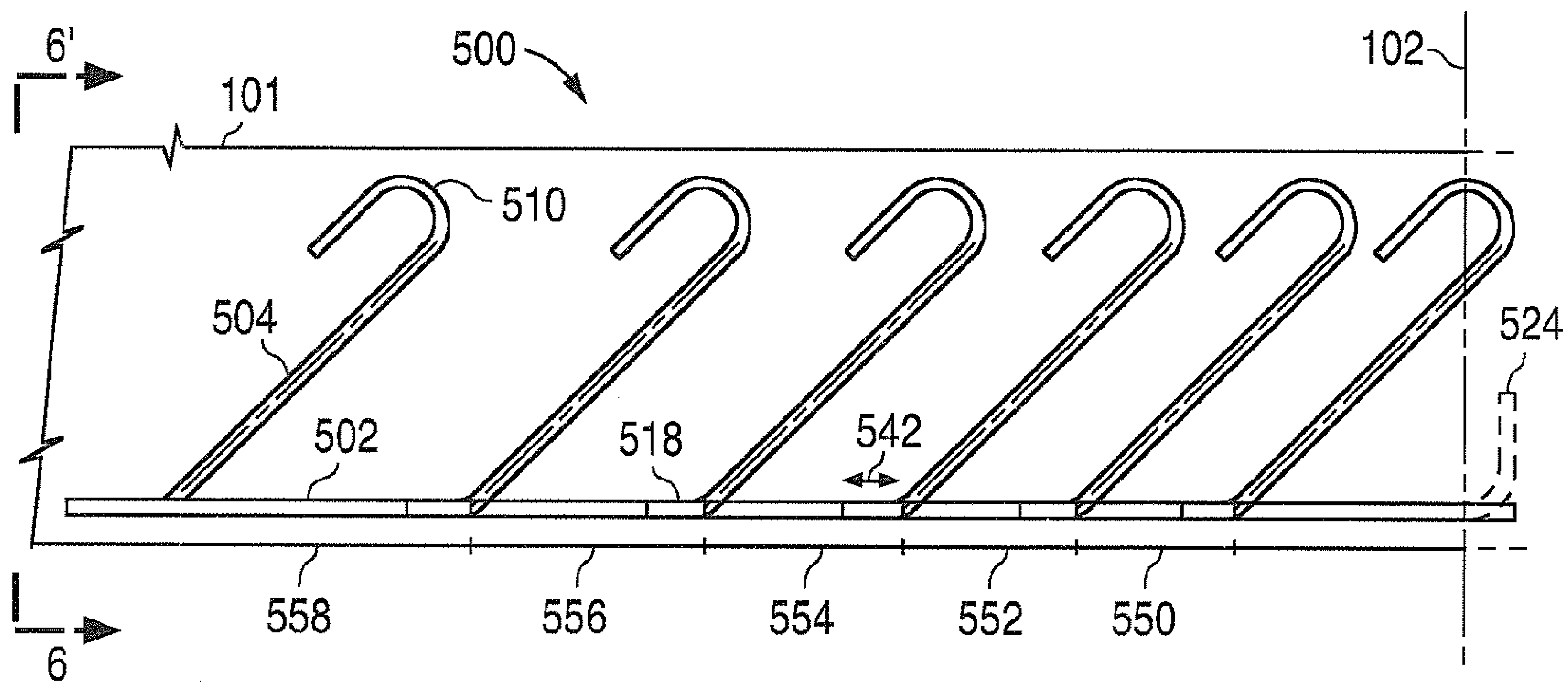
6'
500
101
102
510
504
524
502
518
542
558
556
554
552
550
6

FIG. 5

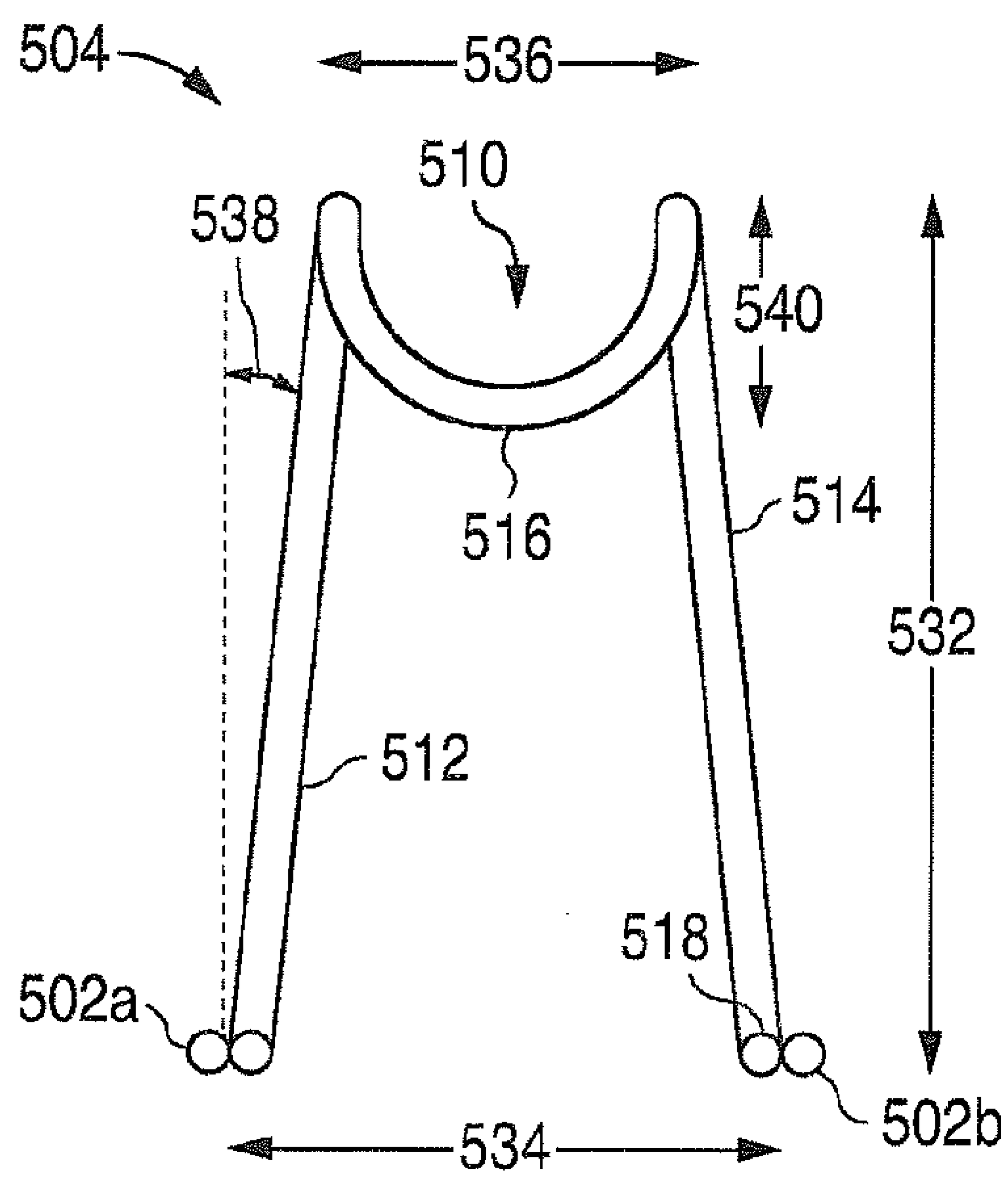
504
536
510
538
540
514
516
532
512
518
502a
502b
534

FIG. 6

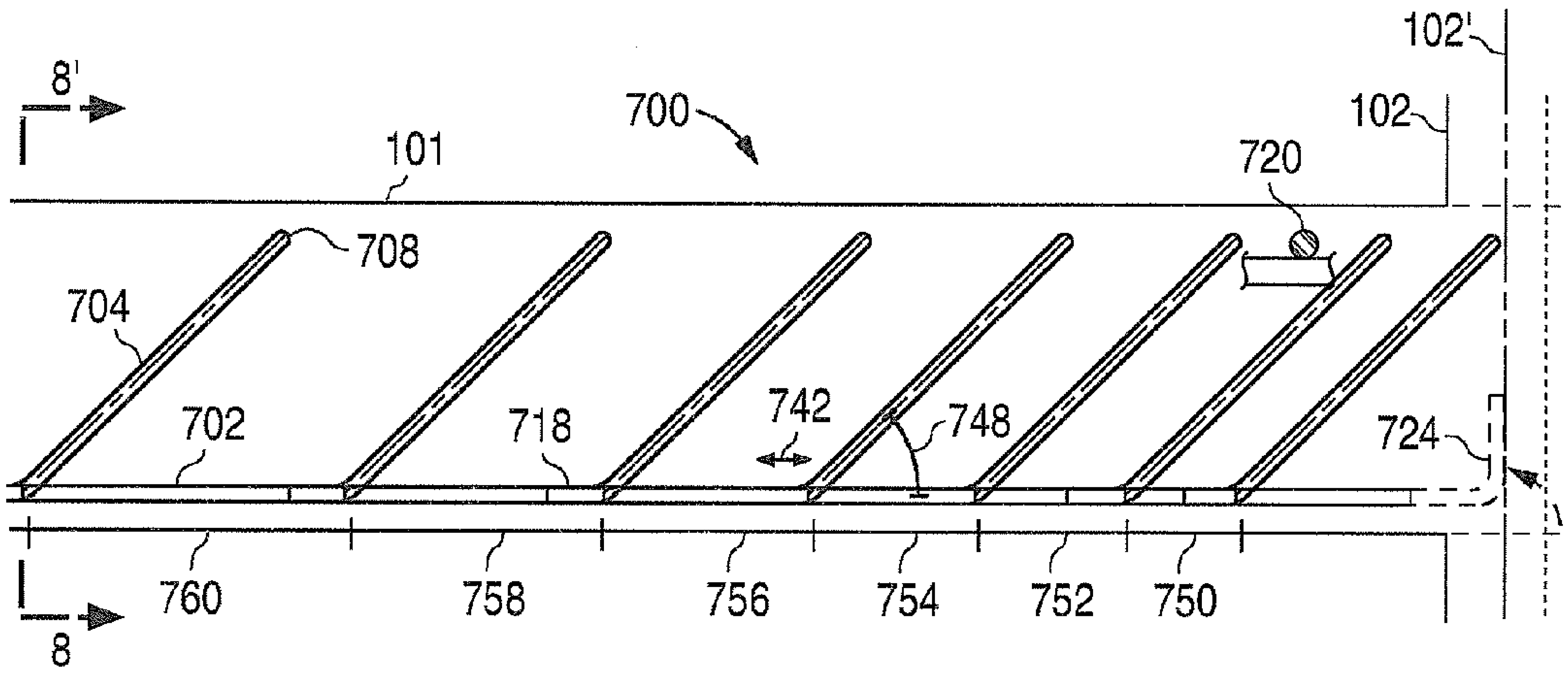
8'
700
101
102'
102
720
708
704
702
718
742
748
724
760
758
756
754
752
750
8

FIG. 7

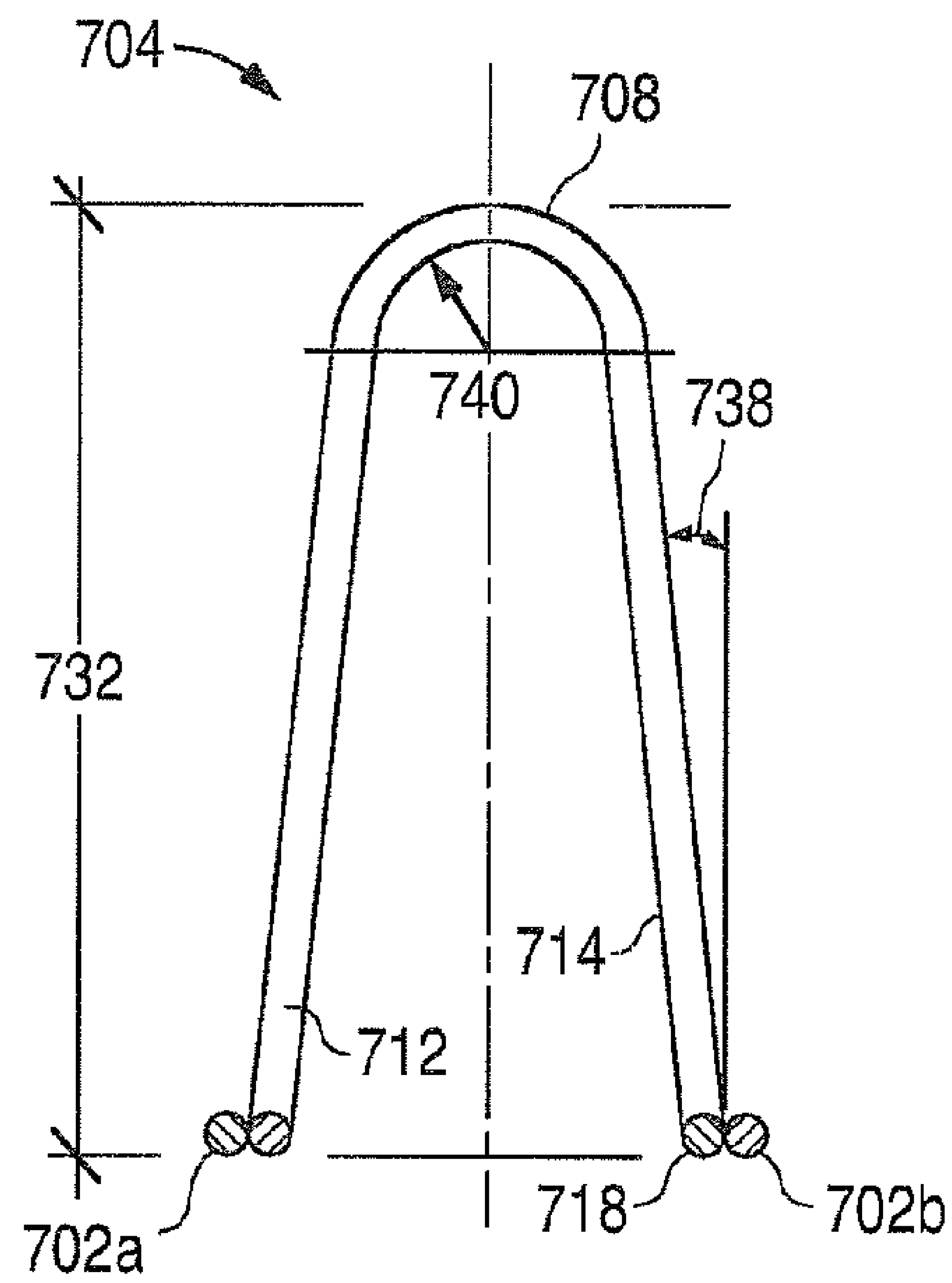
704
708
740
738
732
714
712
702a
718
702b

FIG. 8

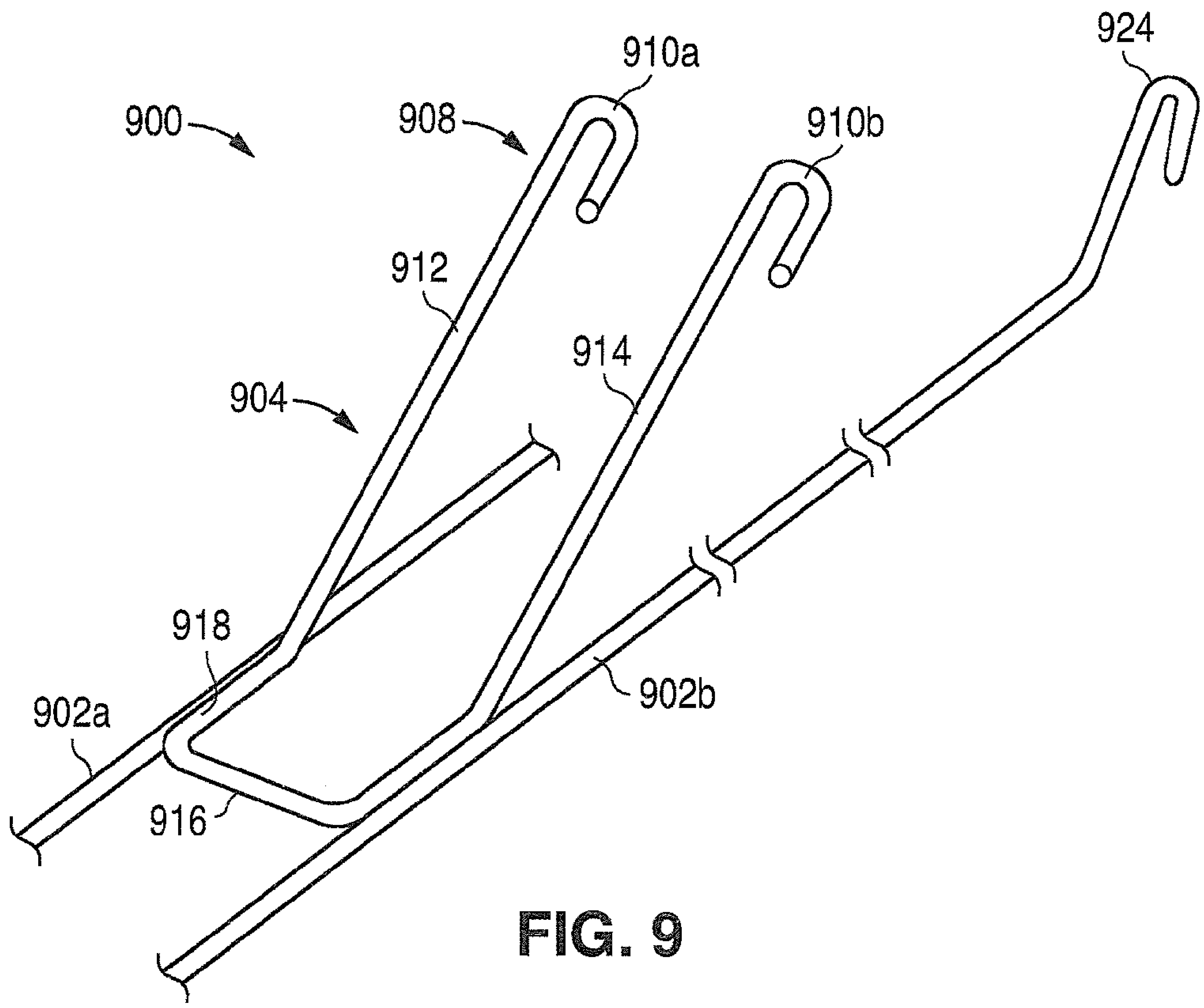

FIG. 9

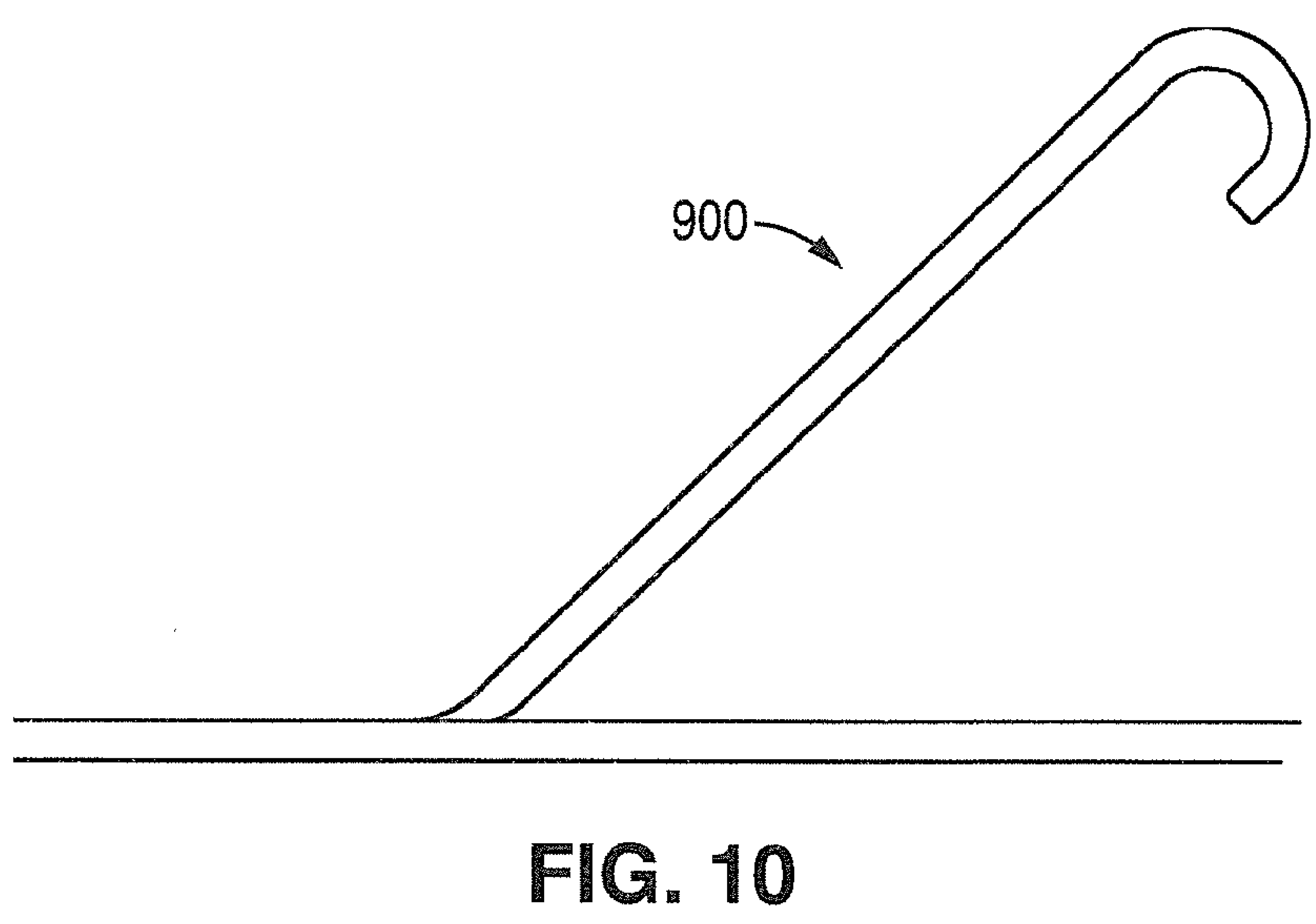

FIG. 10

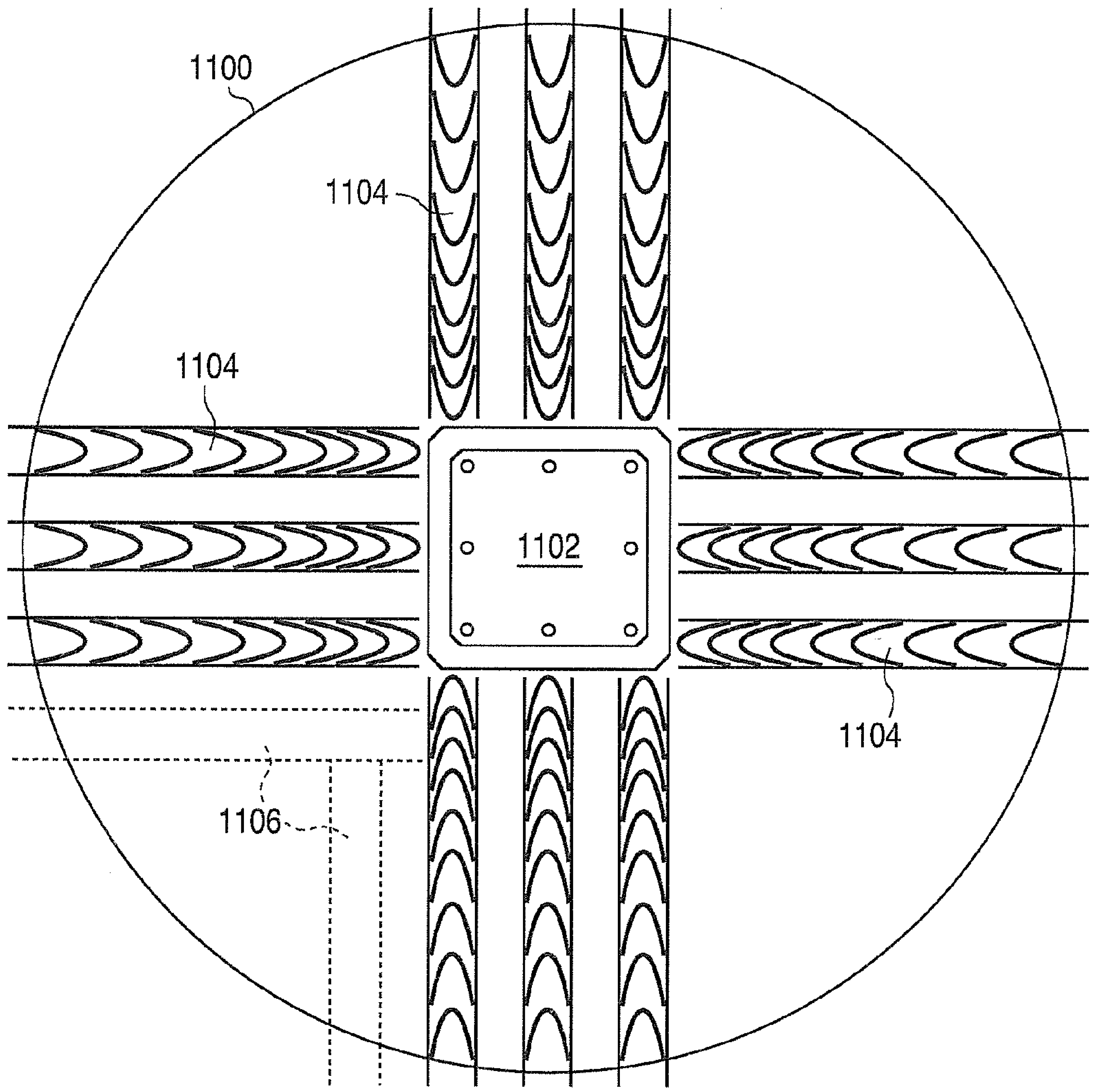

FIG. 11

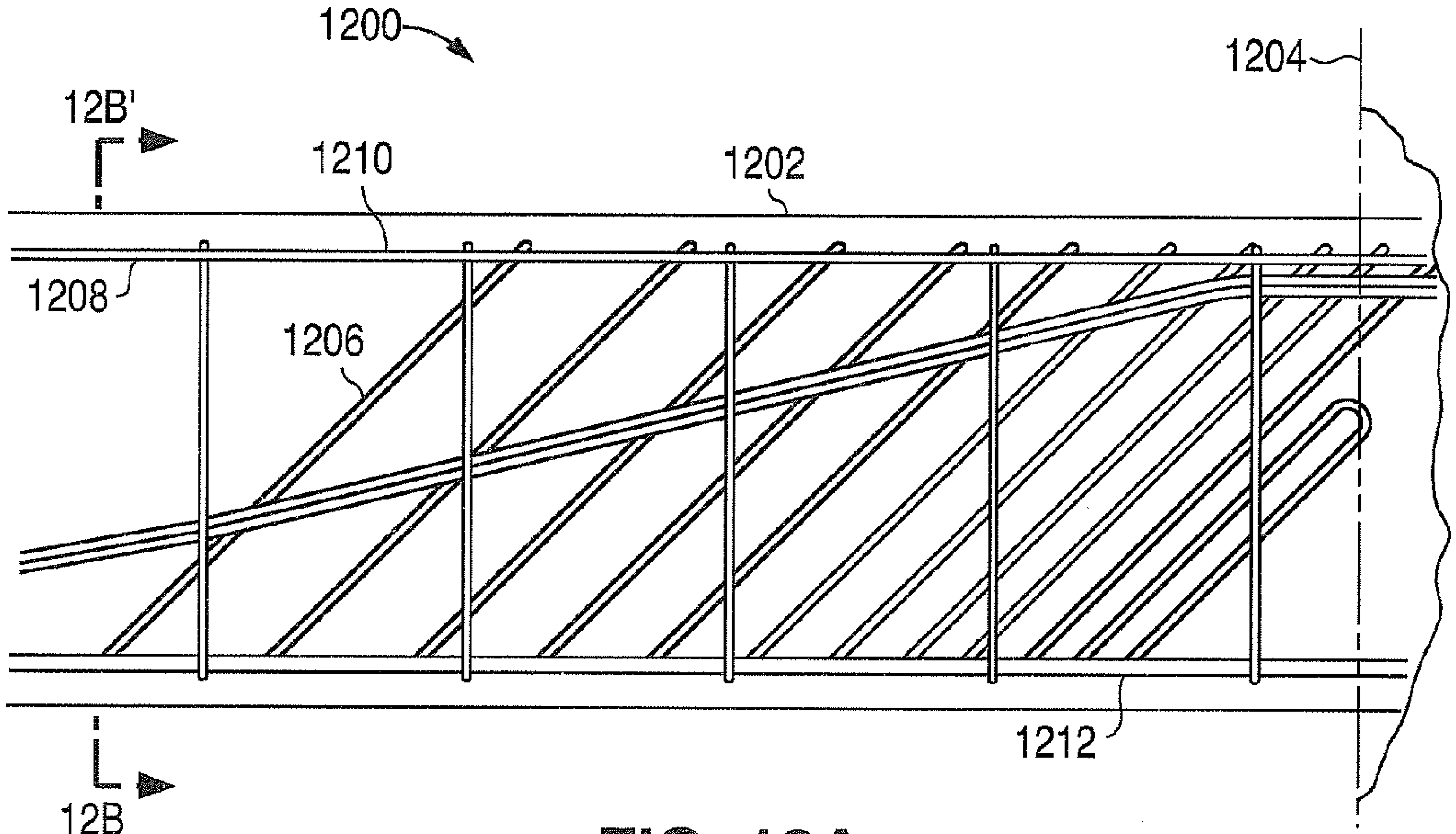

FIG. 12A

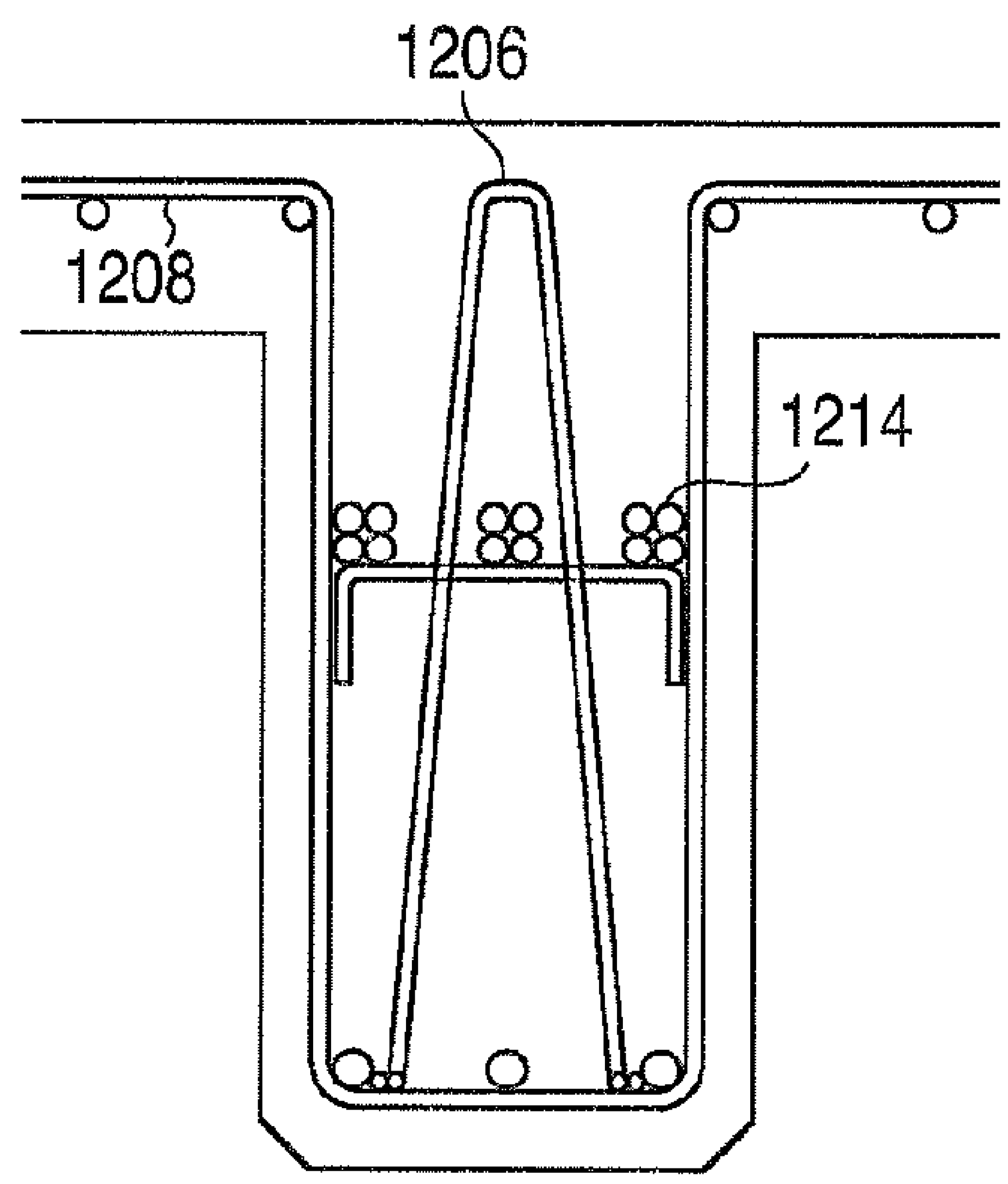

FIG. 12B

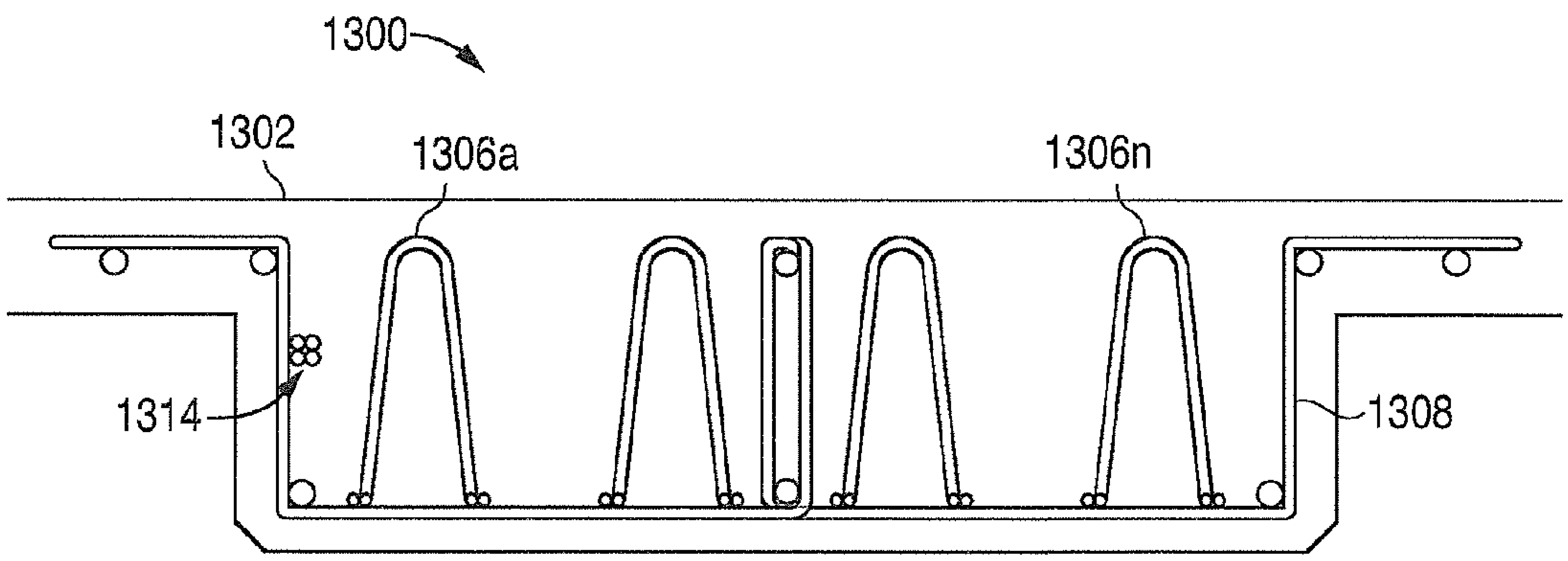

FIG. 13

REINFORCING ASSEMBLY AND REINFORCED STRUCTURE USING A REINFORCING ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION AND PRIORITY CLAIM

This application claims priority under 35 U.S.C. §120 as a continuation-in-part of U.S. patent application Ser. No. 12/959,912 filed on Dec. 3, 2010, now U.S. Pat. No. 8,220, 219 which is hereby incorporated by reference.

TECHNICAL FIELD

This disclosure relates generally to reinforcing structures. More specifically, this disclosure relates to a reinforcing assembly and a reinforced structure (such as a reinforced concrete structure) using a reinforcing assembly.

BACKGROUND

Commercial concrete is a mixture of cement, sand, and stone aggregate that, after the addition of water, slowly hardens together into a rigid structure. Stresses within concrete structures are typically of three primary types: compressive (where particles are crushed together), tensile (where particles are pulled apart), and shear (where one section of a structure is pressured to slide upon an adjacent section).

Unreinforced concrete structures often have good resistance to compressive stresses. However, any significant tensile stresses tend to cause undesirable cracking and separation since concrete is relatively weak in tension. To address this problem, concrete structures are typically reinforced by embedding in place within the rigid structures smaller solid members made of material(s) with high strength in tension. Typically, the smaller members include round steel bars with roughened surfaces, often called "reinforcing steel," "reinforcing bar," or "rebar." Reinforced concrete structures are available commercially in many shapes and sizes, such as slabs, beams, footings, and flat foundations.

Unfortunately, reinforced concrete structures are still highly susceptible to shear forces that create diagonal tensile stresses, which can result in structural failures. Cracking and/or breaking caused by shear forces tend to propagate throughout the stressed zone of a concrete structure. This problem is especially acute in concrete slabs or other supported structures that are supported by columns or other supporting structures. In these types of situations, a slab is subject to a concentration of stresses in a zone near a column, where the column tends to "punch" upward through the slab. The resulting shear forces create diagonal tensile stresses within the supported structure.

For this reason, supported structures are typically reinforced in the areas around columns or other supporting structures. This is done to prevent tensile failure, crack propagation, and consequent structural collapse. However, conventional approaches often provide reinforcement that helps restrain or minimize cracking or breaking only after the cracking or breaking has started. These conventional approaches are typically unable to prevent cracking or breaking from occurring in the first instance.

SUMMARY

This disclosure provides a reinforcing assembly and a reinforced structure (such as a reinforced concrete structure) using a reinforcing assembly.

In a first embodiment, a reinforcing assembly includes multiple spaced-apart, longitudinally-extending support bars. The reinforcing assembly also includes multiple working members each independently connected to the support bars. The working members are oriented diagonally with respect to a longitudinal axis extending along the reinforcing assembly.

In a second embodiment, a reinforced structure includes a supported structure and a reinforcing assembly embedded within the supported structure. The reinforcing assembly includes multiple spaced-apart, longitudinally-extending support bars. The reinforcing assembly also includes multiple working members each independently connected to the support bars. The working members are oriented diagonally with respect to a longitudinal axis extending along the reinforcing assembly.

In a third embodiment, a method includes forming a supported structure having a reinforcing assembly positioned within the supported structure. The reinforcing assembly includes multiple spaced-apart, longitudinally-extending support bars. The reinforcing assembly also includes multiple working members each independently connected to the support bars. The working members are oriented diagonally with respect to a longitudinal axis extending along the reinforcing assembly. The diagonally-oriented working members provide diagonal tension shear reinforcement in the supported structure.

Other technical features may be readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this disclosure and its features, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates an example of a cross-sectional view of a supported structure at an intersection with a supporting structure according to this disclosure;

FIGS. **2** through **4** illustrate a first example of a reinforcing assembly according to this disclosure;

FIGS. **5** and **6** illustrate a second example of a reinforcing assembly according to this disclosure;

FIGS. **7** and **8** illustrate a third example of a reinforcing assembly according to this disclosure;

FIGS. **9** and **10** illustrate a fourth example of a reinforcing assembly according to this disclosure; and

FIGS. **11** through **13** illustrate examples of supported structures containing reinforcing assemblies according to this disclosure.

DETAILED DESCRIPTION

FIGS. **1** through **13**, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the invention may be implemented in any type of suitably arranged device or system.

FIG. **1** illustrates an example of a cross-sectional view **100** of a supported structure at an intersection with a supporting structure according to this disclosure. In this example, a slab structure **101** (the supported structure) is attached to a support column **102** (the supporting structure). The slab structure **101** can be formed from any suitable material(s), such as concrete or steel-supported concrete. The column **102** can also be formed from any suitable material(s), such as concrete or steel-supported concrete.

The slab structure **101** typically includes internal structural components that provide reinforcement. These internal components can represent any suitable structure(s) formed from any suitable material(s), such as reinforcing bar ("rebar") **103** formed of carbon steel or other material(s). The rebar **103** can be placed down the length of the slab structure **101** and/or across the width of the slab structure **101**. In some embodiments, the rebar **103** extends across the top of the slab structure **101** (into and out of the view as shown), as well as across the bottom of the slab structure **101**. However, both may not be needed, such as when rebar **103** is used across only the top of the slab structure **101**.

In this example, a load or "reaction" area **104** of the slab structure **101** represents an area where large upward forces can exist, creating punching shear forces in the slab structure **101**. Here, the punching shear forces are creating undesirable diagonal tension cracks **105** in the slab structure **101**. The cracks **105** can form particularly in areas of high stress of the slab structure **101**. Many times, the cracks **105** can form generally in the middle or upper area of the slab structure **101** and can propagate upward and downward, often in a diagonal direction, if not impeded. As described in more detail below, various reinforcing assemblies are disclosed here that can help to reduce or even eliminate the formation of cracks caused by shear forces in a slab structure **101** or other similarly supported structure.

Although FIG. **1** illustrates one example of a cross-sectional view **100** of a supported structure at an intersection with a supporting structure, various changes may be made to FIG. **1**. For example, each of the components in FIG. **1** could have any suitable size, shape, and dimensions. Also, the reinforcing assemblies described below could be used in any other environment where shear forces affect a structure, such as with any suitable supported structure that is supported by any suitable supporting structure.

FIGS. **2** through **4** illustrate a first example of a reinforcing assembly **200** according to this disclosure. In particular, FIG. **2** is an elevation view of the reinforcing assembly **200**, and FIG. **3** is a sectional view taken along lines **3-3'** in FIG. **2**. FIG. **4** illustrates section, elevation, and plan views of a working member of the reinforcing assembly **200**. In these figures and the following description, it is assumed that the reinforcing assembly **200** is used in conjunction with the slab structure **101** and the support column **102**. However, the reinforcing assembly **200** could be used with any other supported structure or any other supporting structure.

As shown in FIG. **2**, the reinforcing assembly **200** includes two spaced-apart, longitudinally-extending support or carrier bars **202***a*-**202***b* (referred to collectively as bars **202**). In some embodiments, each of the support bars **202** could represent a single continuous bar, although support bars **202** formed from multiple connected segments could be used. Also, each of the support bars **202** could have any suitable cross-sectional shape. Multiple working members **204** are independently connected to the support bars **202**. In some embodiments, each working member **204** could represent a single integral unit that is attached at two weld points to the support bars **202**. The working members **204** and the support bars **202** can be formed from any suitable material(s), such as rebar. The rebar could have the smallest practical diameter (such as #3 rebar) and have a ribbed or knurled surface along its entire length.

FIG. **2** shows a side view of the working members **204**, while FIG. **3** shows a front or rear view of the working members **204**. As shown in FIG. **2**, each working member **204** is oriented diagonally with respect to a longitudinal axis **206** that extends along the support bars **202**. Through this diagonal orientation, the working members **204** can more effectively impede diagonal crack formation in the slab structure **101** and possibly even prevent the formation of cracks **105**.

As shown in FIGS. **3** and **4**, each working member **204** includes a top portion **208**, which defines the upper extent of the working member **204**. The top portion **208** is also the point from which a downwardly-extending hook portion **210** of the working member **204** extends. Each working member **204** includes first and second upstanding sides **212-214** and a central connecting section **216** that connects the upstanding sides **212-214**. Each upstanding side **212-214** also has a connecting portion **218**, which is generally parallel with the support bars **202**. The connecting portions **218** can be welded or otherwise connected to the support bars **202** (such as to an inside face of the support bar **202**).

The "turn-down" created by the hook portion **210** at the top of each working member **204** facilitates near full anchorage along the top of the slab structure **101**. At the same time, the hook portion **210** at the top of each working member **204** can ensure that the reinforcing assembly **200** does not block rebar **220** in either direction (the rebar **220** typically is not part of the shear reinforcing assembly **200** itself). This configuration allows the uppermost portions of the working members **204** to extend to a close distance (such as 0.75 inches) from the top surface of the slab structure **101**. The bottom of the reinforcing assembly **200** could be the same or similar distance (such as 0.75 inches) from the bottom surface of the slab structure **101**. This can allow the working members **204** to engage substantially the full thickness of the slab structure **101** and provide full efficiency.

The central connecting section **216** of each working member **204** connects the upstanding sides **212-214** of that working member **204** to one another so that each working member **204** is an integral unit. The central connecting section **216** therefore provides a stabilizing connection between the two sides of each working member **204**.

As noted above, each working member **204** is angled with respect to the support bars **202**. More specifically, the upstanding sides **212-214** are angled with respect to the support bars **202**. An angle **222** could have any suitable value, such as about 20° to about 70°. In particular embodiments, the angle **222** is about 45°. As shown in FIG. **4**, this bend allows for a longitudinal weld between the support bars **202** and the connecting portions **218** of the working member **204**. The weld may be extended as required to develop the full strength of the support bars **202**. The weld can also be stressed longitudinally and thus is able to develop the full strength of the working members **204** and to provide full bottom anchorage.

As shown in FIG. **2**, each longitudinally-extending support bar **202** can optionally terminate at the column **102** in a structure **224** that is bent upward and hooked. This structure **224** is designed to extend into the support column **102** and provide additional support and gripping action in an area of maximum stress and load transfer.

The working members **204** can be spaced along the support bars **202** at any suitable fixed or variable distance(s). In FIG. **2**, the spacing between adjacent pairs of working members **204** along the length of the reinforcing assembly **200** varies in different sections **226-230**. Here, the spacing between adjacent working members **204** in the first section **226** is closer than in the second section **228**, and the spacing between adjacent working members **204** in the second section **228** is closer than in the third section **230**. In particular embodiments, the spacing between adjacent working members **204** is about three or four inches in the first section **226**, about five inches in the second section **228**, and about six or seven inches in the third section **230**.

Other progressively-increasing spacings could also be used. For example, each successive spacing away from the column **102** could be a fixed percentage larger than the preceding spacing, and no spacings (except possibly the first few spacings) could be equal. As another example, the spacings could vary incrementally in fractional-inch or other increments. In some embodiments, the smallest spacing between two working members **204** could be about three to about four inches, and the largest spacing between two working members **204** could be about ten inches.

The spacings and the lengths of the working members **204** for any particular installation could be based on various factors. Example factors include the thickness of the slab structure **101**, the load to be placed on the slab structure **101**, the strength of the concrete or other material(s) forming the slab structure **101**, and the size of the column **102**. In general, any technique for increasing the spacings between at least some of the adjacent pairs of working members **204** along the length of the reinforcing assembly **200** could be used. Note that the use of smaller spacings closer to the column **102** allows the reinforcing assembly **200** to provide greater reinforcement closer to the support column **102**. However, variable spacing is not required in the reinforcing assembly **200**.

The following are example values for other dimensions of the reinforcing assembly **200**. The reinforcing assembly **200** could have a height **232** of about seven inches to about ten inches. The height **232** could be about 1.5 inches shorter than the height of the slab structure **101**, allowing for about 0.75 inches on top and bottom of the reinforcing assembly **200**. Each of the working members **204** could have a width **234** on bottom of about 4.25 inches and a width **236** on top of about 3.25 inches. The wider width at the bottom provides stability against overturning and can allow multiple assemblies to be stacked after fabrication (to reduce volume during shipping). Each connecting portion **218** could have a length **237** of about two inches. Each hook portion **210** could form an angle **238** of about 75° and extend downward at a distance **240** of about 2.25 inches. Each hook portion **210** could also have a width **242** of about 3.25 inches and a length **244** of about 3.125 inches. These dimensions are for illustration only.

As shown in FIGS. **2** through **4**, each of the working members **204** can be bent into five different planes before being connected to the support bars **202**. Automated machinery could be used to bend the rebar or other materials to form the working members **204**, such as in a single pass.

The working members **204** are placed diagonally on the support bars **202** to engage any nascent crack **105** in the slab structure **101** at a 90° or near 90° angle with respect to the crack **105** itself, which provides improved or maximum efficiency in terms of aligning the working members **204** to directly oppose the diagonal tension (splitting) forces. With diagonal placement, each working member **204** traverses a much larger percentage of the potential crack zone per unit length as compared to a vertical orientation. The diagonal placement also enables each working member **204** to engage up to twice as many crack zones per unit. Further, the compact size and alignment of the working members **204** allow the working members **204** to penetrate upward, even between densely-packed top rebar concentrations, and to engage the full depth of structural slab thickness.

Although the use of small (roughened) rebar could mean that more working members are required per installation, this provides an advantage in that it allows a more dispersed distribution of the individual working members in concrete. As a result, the reinforcing can "blend" into the concrete material and act more as an integral part of the concrete itself.

FIGS. **5** and **6** illustrate a second example of a reinforcing assembly **500** according to this disclosure. In particular, FIG. **5** is an elevation view of the reinforcing assembly **500**, and FIG. **6** is a sectional view taken along lines **6-6'** of FIG. **5**. In these figures and the following description, it is again assumed that the reinforcing assembly **500** is used in conjunction with the slab structure **101** and the support column **102**. However, the reinforcing assembly **500** could be used with any other supported structure or any other supporting structure.

The reinforcing assembly **500** includes multiple support bars **502***a*-**502***b* (referred to collectively as bars **502**) and multiple working members **504**. The working members **504** are again oriented diagonally with respect to a longitudinal axis that extends along the support bars **502**. Each working member **504** includes an upwardly-extending hook portion **510**. Each working member **504** also includes first and second upstanding sides **512-514** and a central connecting section **516** that connects the upstanding sides **512-514**. Each upstanding side **512-514** also has a connecting portion **518**, which can be welded or otherwise connected to one of the support bars **502**. The working members **504** are similar in structure to the working members **204**, except the hook portions **510** of the working members **504** are made to hook upward instead of downward.

In this example, each of the support bars **502** can optionally terminate within the support column **102** in a structure **524** that is bent upward. Again, the structure **524** is designed to extend into the support column **102** and provide additional support and gripping action in an area of maximum stress and load transfer.

The following are example values for various dimensions and other characteristics of the reinforcing assembly **500**. The support bars **502** and working members **504** can be formed from #3 rebar. The reinforcing assembly **500** could have a height **532** that is about 1.5 inches shorter than the height of the slab structure **101**, allowing for about 0.75 inches on top and bottom of the reinforcing assembly **500**. The reinforcing assembly **500** could, for example, have a height **532** of about 7.5 inches. Each of the working members **504** could have a width **534** on bottom of about 5.5 inches and a width **536** on top of about 2.5 inches. The upstanding sides **512-514** could be angled at an angle **538** of about 6°, and the hook portion **510** could extend downward at a distance **540** of about 1.5 inches. Each of the connecting portions **518** could have a length **542** of about 1.5 inches.

Once again, the spacings between adjacent working members **504** could be fixed or variable in any suitable manner. For instance, spacings **550-558** could be about 4.125 inches, about 4.375 inches, about five inches, about six inches, and about 7.5 inches, respectively. However, any other suitable spacing(s) could be used.

FIGS. **7** and **8** illustrate a third example of a reinforcing assembly **700** according to this disclosure. In particular, FIG. **7** is an elevation view of the reinforcing assembly **700**, and FIG. **8** is a sectional view taken along lines **8-8'** of FIG. **8**. In these figures and the following description, it is once again assumed that the reinforcing assembly **800** is used in conjunction with the slab structure **101** and the support column **102**. In this example, the support column **102** is shown to include column rebar **102'**. However, the reinforcing assembly **800** could be used with any other supported structure or any other supporting structure.

The reinforcing assembly **700** includes multiple support bars **702***a*-**702***b* (referred to collectively as bars **702**) and multiple working members **704**. The working members **704** are again oriented diagonally with respect to a longitudinal axis that extends along the support bars **702**. Each working member **704** includes a top portion **708**, first and second upstanding sides **712-714**, and a central connecting section **716** that connects the upstanding sides **712-714**. Unlike the reinforcing assemblies **200** and **500**, the working members **704** here lack a longitudinal hook portion, and the top portion **708** is substantially planar with the upstanding sides **712-714**. Each upstanding side **712-714** has a connecting portion **718**, which can be welded or otherwise connected to one of the support bars **702**.

This embodiment of the reinforcing assembly can be simpler to manufacture since the working members **704** require fewer bends than the assemblies shown in FIGS. **2** and **5**. Also, this embodiment of the reinforcing assembly could be more easily integrated with rebar **720** in the slab structure **101**. The rebar **720** can be placed between the working members **704** in one direction and, if desired, next to or through the loops formed by the top portions **708** of the working members **704** in the other direction.

In this example, each of the support bars **702** can optionally terminate within the support column **102** in a structure **724** that is bent upward. Once again, the structure **724** is designed to extend into the support column **102** and provide additional support and gripping action in an area of maximum stress and load transfer.

The following are example values for various dimensions and other characteristics of the reinforcing assembly **700**. The support bars **702** and working members **704** can be formed from #3 rebar. The reinforcing assembly **700** could have a height **732** that is about 1.5 inches shorter than the height of the slab structure **101**, allowing for about 0.75 inches on top and bottom of the reinforcing assembly **700**. Each of the working members **704** could have upstanding sides **712-714** at an angle **738** of about 6°, and the top portion **708** could have an inner radius of curvature **740** of about one inch. Each of the working members **704** could also have connecting portions **718** with a length **742** of about 1.5 inches, and the working members **704** could be placed at an angle **748** of about 45°±25° on the support bars **702**.

The spacings between adjacent working members **704** could be fixed or variable in any suitable manner. For instance, the spacings **750-760** could be about three inches, about 3.5 inches, about 4.25 inches, about 5.25 inches, about 6.5 inches, and about eight inches, respectively. However, any other suitable spacing(s) could be used. Moreover, since the working members **704** lack longitudinal hook structures, a closer spacing could be achieved in the reinforcing assembly **700**.

FIGS. **9** and **10** illustrate a fourth example of reinforcing assembly **900** according to this disclosure. In particular, FIG. **9** is an offset view of the reinforcing assembly **900**, and FIG. **10** is an elevation view of a working member of the reinforcing assembly **900**.

The reinforcing assembly **900** includes multiple support bars **902***a*-**902***b* (referred to collectively as bars **902**) and multiple working members **904** (although a single working member **904** is shown in FIG. **9**). Each working member **904** includes a top portion **908**, first and second upstanding sides **912-914**, and a central connecting section **916** that connects the upstanding sides **912-914**. However, in this embodiment, the central connecting section **916** connects the lower ends of the upstanding sides **912-914**, the upstanding sides **912-914** are unconnected at the top portion **908**. The upstanding sides **912-914** continue to be oriented diagonally with respect to a longitudinal axis that extends along the support bars **902**. Each upstanding side **912-914** could have a connecting portion **918**, which can be welded or otherwise connected to one of the support bars **902**.

In this example, the upstanding sides **912-914** of the working member **904** include two hook portions **910***a*-**910***b*. The hook portions **910***a*-**910***b* hook downward in this embodiment, although the hook portions **910***a*-**910***b* could also hook upward similar to FIG. **5**. The hook portions **910***a*-**910***b* are not connected to each other since the central connecting section **916** is connected to the lower ends of the upstanding sides **912-914**. Note, however, that multiple central connecting sections **916** could be used, one on bottom of the upstanding sides **912-914** and one connecting the hook portions **910***a*-**910***b*.

The following are example values for various dimensions and other characteristics of the reinforcing assembly **900**. The support bars **902** and working members **904** can be formed from #3 rebar. The reinforcing assembly **900** could have a height that is about 1.5 inches shorter than the height of the slab structure **101**, allowing for about 0.75 inches on top and bottom of the reinforcing assembly **900**. The upstanding sides **912-914** could be separated by about four inches, and each connecting portion **918** could be about 1.25 inches in length (with a bottom filet weld of about one inch long). Each of the hook portions **910***a*-**910***b* could have a radius of curvature of about 0.75 inches and could extend downward about two inches. The working members **904** could be placed at an angle of about 45°±25° on the support bars **902**.

In particular embodiments, each working member in the above-described reinforcing assemblies is oriented diagonally, has a knurled or other rough surface (possibly along its full length), and is formed of a small diameter rebar material (such as #3 rebar). This size of rebar could have the highest ratio of surface area-to-cross sectional area (thus increasing its ability to bond most effectively to concrete around it, which can be very useful since the confinement of the slab thickness may severely limit the length of the working members) while being stiff enough to maintain its shape during concrete placement. The use of #3 rebar is not a requirement, however, and other types of materials (such as #4 rebar or #5 rebar) may be used. Moreover, while the reinforcing assemblies are illustrated as having multiple diagonal working members whose spacing from one another varies progressively from an inner to an outer end (relative to the supporting structure), this is not a requirement, either. A reinforcing assembly with at least one diagonal working member having the structural characteristics described and illustrated above is within the scope of this disclosure.

The reinforcing assemblies described above can provide various advantages over conventional approaches (depending on the implementation). The angled (diagonal) orientation of the working members places them at approximately a perpendicular position to potential diagonal-stress punching shear cracks. The ribbed or other roughened surfaces of the working members provide improved or maximum efficiency in engaging concrete at the points of maximum stress, helping to prevent cracks from beginning in the first instance. Because the reinforcing assemblies can inhibit cracks at the points of maximum stress and because the reinforcing assemblies can provide similar reinforcement that crosses the crack zones above and below these points and not far from them, any crack (if it does occur) cannot propagate (extend) upward or downward. If cracking does not occur or if it is held to a very narrow width, the very significant strength of the concrete continues to maintain its integrity and work as a single solid unit as it was designed to do, thereby enabling the supported structure (in which a reinforcing assembly is embedded) to carry maximum shear loads. The rebar and the concrete thus work together, and their respective strengths are additive, rather than (as in the prior art) the concrete failing and transferring all of its load-carrying ability to smooth steel studs (such as in the STUD-RAIL system) or similar reinforcing.

The reinforcement provided by each angled working member develops a bond with the concrete with which it is in contact, thus preventing crack origination and/or propagation. This is because the working member bonds to the concrete on both sides on the crack zone and prevents those concrete segments from moving apart from one another. Thus, the cracking process cannot begin under usual loads. The rebar works with the concrete and supplements it, rather than simply going to work after the concrete has already failed (as in the STUD-RAIL system).

The reinforcing assemblies are easy to manufacture. Each assembly can be made entirely of available materials (such as #3 rebar), and those pieces are readily bent and welded into the assembly using conventional manufacturing techniques (which can be automated).

Although FIGS. **2** through **10** illustrate examples of reinforcing assemblies for use with concrete structures or other supported structures, various changes may be made to FIGS. **2** through **10**. For example, the relative sizes and dimensions of components in each figure are for illustration only. Also, features in one or more of these figures could be used in one or more others of these figures.

FIGS. **11** through **13** illustrate examples of supported structures containing reinforcing assemblies according to this disclosure. FIG. **11** illustrates an example plan view of a supported structure **1100** containing multiple reinforcing assemblies. In this example, the supported structure **1100** represents a slab or other structure that is supported by a column or other supporting structure **1102**. A concrete column is typically about 16 to about 24 inches square, although other sizes and shapes could be used. Note that a column is but one example type of supporting structure **1102** that could be used here.

In this example embodiment, three reinforcing assemblies **1104** are positioned side-by-side at each orthogonal position around the supporting structure **1102**. The reinforcing assemblies **1104** could represent any of the reinforcing assemblies described above, and the reinforcing assemblies **1104** may or may not be identical in structure. The reinforcing assemblies **1104** extend outwardly to provide an overall zone of reinforcement around the supporting structure **1102**. The reinforcing assemblies **1104** could be between about two feet to about four feet in length, although any other suitable length(s) could be used. Note that one or more additional reinforcing assemblies **1106** could be used in one or both directions for high-stress conditions.

FIGS. **12**A and **12**B illustrate another example supported structure **1200** containing a reinforcing assembly. In this example, the supported structure **1200** includes a long-span deep beam **1202** that is supported by a column or other supporting structure **1204**. Here, the beam **1202** includes a reinforcing assembly **1206** within a beam stirrup **1208**. The reinforcing assembly **1206** could represent any of the reinforcing assemblies described above. In this example, a single reinforcing assembly **1206** is placed within the beam stirrup **1208**, which forms a U-shaped recess in which the reinforcing assembly **1206** is placed. For additional support, the beam **1202** also includes top and bottom rebar **1210-1212**, as well as post-tensioning strands **1214** (which could be formed from wire rope of extremely high-tensile steel that does not bond to concrete).

FIG. **13** illustrates yet another example supported structure **1300** containing multiple reinforcing assemblies. In this example, the supported structure **1300** includes a wide shallow beam **1302**, which can be supported by a column or other supporting structure. Here, the beam **1302** includes multiple reinforcing assemblies **1306*a*-1306*n*** within a beam stirrup **1308**. The reinforcing assemblies **1306*a*-1306*n*** could represent any of the reinforcing assemblies described above and need not all be identical. In this example, the beam stirrup **1308** forms a large U-shaped recess in which the reinforcing assemblies **1306*a*-1306*n*** are placed. For additional support, the beam **1302** could include additional structures, such as top or bottom rebar or post-tensioning strands **1314**.

Although FIGS. **11** through **13** illustrate examples of supported structures containing reinforcing assemblies, various changes may be made to FIGS. **11** through **13**. For example, any number of reinforcing assemblies could be used in each structure. Also, any other supported structure(s) could be used with the reinforcing assemblies. For instance, a reinforced concrete structure includes any structure (such as a slab, beam, footing, flat foundation, or the like) that includes at least one reinforcing assembly.

It may be advantageous to set forth definitions of certain words and phrases used throughout this patent document. The terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation. The term "or" is inclusive, meaning and/or. The phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, have a relationship to or with, or the like.

While this disclosure has described certain embodiments and generally associated methods, alterations and permutations of these embodiments and methods will be apparent to those skilled in the art. Accordingly, the above description of example embodiments does not define or constrain this disclosure. Other changes, substitutions, and alterations are also possible without departing from the spirit and scope of this disclosure, as defined by the following claims.

What is claimed is:

1. A reinforcing assembly for use in a reinforced concrete structure, the reinforcing assembly comprising:

multiple spaced-apart, longitudinally-extending support bars; and

multiple working members each independently connected to the support bars, the working members oriented diagonally with respect to a longitudinal axis extending along the support bars;

wherein the working members are arranged so that a lower portion of one working member is physically located directly between an upper portion of a neighboring working member and each support bar in a direction perpendicular to the longitudinal axis;

wherein the support bars and the working members comprise rebar, the working members welded to the support bars; and

wherein each working member comprises upwardly-extending sides and a connecting portion that couples the upwardly-extending sides.

2. The reinforcing assembly of claim **1**, wherein the connecting portion of each working member includes a hook portion at upper ends of the upwardly-extending sides.

3. The reinforcing assembly of claim **1**, wherein:

each working member includes separate hook portions at upper ends of the upwardly-extending sides; and the connecting section of each working member connects the upwardly-extending sides at lower ends of the upwardly-extending sides.

4. The reinforcing assembly of claim 1, wherein the connecting portion in each working member includes a loop connecting the upwardly-extending sides, the upwardly-extending sides and the loop being substantially planar.

5. The reinforcing assembly of claim 1, wherein each upwardly-extending side has, at a lower end, a second connecting portion that connects the upwardly-extending side to one of the support bars.

6. The reinforcing assembly of claim 1, wherein the support bars and the working members comprise #3 rebar.

7. The reinforcing assembly of claim 1, wherein the working members are oriented at about 45° with respect to the longitudinal axis.

8. The reinforcing assembly of claim 1, wherein each support bar comprises a section that is bent upward and that is configured to be anchored within a supporting structure.

9. The reinforcing assembly of claim 1, wherein at least some of the working members are spaced a variable distance apart.

10. The reinforcing assembly of claim 2, wherein the hook portion of each working member comprises one of: an upwardly-extending hook portion and a downwardly-extending hook portion.

11. The reinforcing assembly of claim 1, wherein:

the upwardly-extending sides of each working member are substantially straight; and

the upwardly-extending sides of all working members connected to the support bars are substantially parallel with each other when the reinforcing assembly is viewed from a side.

12. A reinforced structure comprising:

a concrete supported structure; and

a reinforcing assembly embedded within the concrete supported structure, wherein the reinforcing assembly comprises:

multiple spaced-apart, longitudinally-extending support bars; and

multiple working members each independently connected to the support bars, the working members oriented diagonally with respect to a longitudinal axis extending along the support bars;

wherein the working members are arranged so that a lower portion of one working member is physically located directly between an upper portion of a neighboring working member and each support bar in a direction perpendicular to the longitudinal axis;

wherein the support bars and the working members comprise rebar, the working members welded to the support bars; and

wherein each working member comprises upwardly-extending sides and a connecting portion that couples the upwardly-extending sides.

13. The reinforced structure of claim 12, wherein the connecting portion of each working member includes a hook portion at upper ends of the upwardly-extending sides.

14. The reinforced structure of claim 13, wherein the hook portion of each working member comprises one of: an upwardly-extending hook portion and a downwardly-extending hook portion.

15. The reinforced structure of claim 12, wherein:

each working member includes separate hook portions at upper ends of the upwardly-extending sides; and

the connecting section of each working member connects the upwardly-extending sides at lower ends of the upwardly-extending sides.

16. The reinforced structure of claim 12, wherein the connecting portion in each working member includes a loop connecting the upwardly-extending sides, the upwardly-extending sides and the loop being substantially planar.

17. The reinforced structure of claim 12, wherein each upwardly-extending side has, at a lower end, a second connecting portion that connects the upwardly-extending side to one of the support bars.

18. The reinforced structure of claim 12, wherein the supported structure comprises a concrete slab.

19. The reinforced structure of claim 18, wherein the concrete slab is supported by at least one concrete column.

20. The reinforced structure of claim 12, wherein each support bar comprises a section that is bent upward and that is configured to be anchored within a supporting structure.

21. A method comprising:

forming a concrete supported structure having a reinforcing assembly positioned within the supported structure, the reinforcing assembly comprising:

multiple spaced-apart, longitudinally-extending support bars; and

multiple working members each independently connected to the support bars, the working members oriented diagonally with respect to a longitudinal axis extending along the support bars;

wherein the working members are arranged so that a lower portion of one working member is physically located directly between an upper portion of a neighboring working member and each support bar in a direction perpendicular to the longitudinal axis;

wherein the support bars and the working members comprise rebar, the working members welded to the support bars; and

wherein each working member comprises upwardly-extending sides and a connecting portion that couples the upwardly-extending sides.

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